The Electric Ship and Electric Weapons

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NAVSEA Dahlgren

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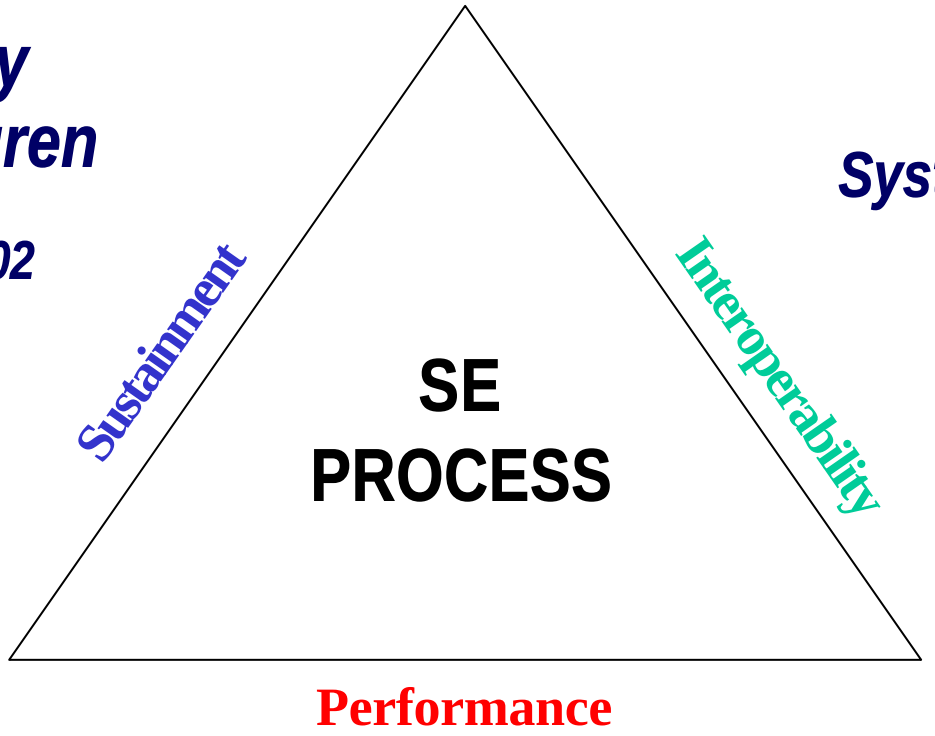


Topics

- Why
- Directed Energy Weapons
- Electromagnetic Launch Weapons
- Weapons Integration
- Conclusion

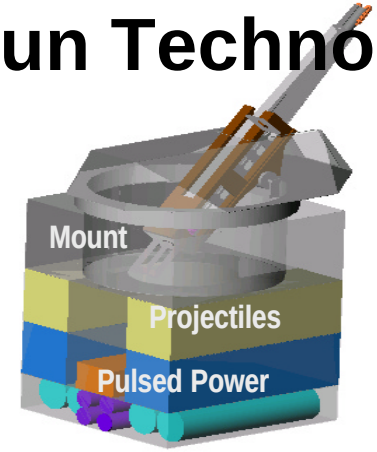
Why Electric Weapons?

- **Improve Warfighting Capability**
  - Lower Cost per Shot
  - Reduced Time to Target
  - Greater Range
  - Reduced Ship Vulnerability
  - Simplified Logistics
- **Leap-Ahead Technologies**
  - Speed of Light and Hypersonic Response
  - Eliminate Shipboard Energetics
    - ★ Fuel converted to Kinetic Energy Projectiles
    - ★ Fuel converted to Variable Lethality

Why Now?

Integrated Power System (IPS)

Demonstration of Railgun Technology



Advances in Laser Technology

Timely Coincidence!

What Has Changed?

Electric Drive selected for Future Navy Destroyer

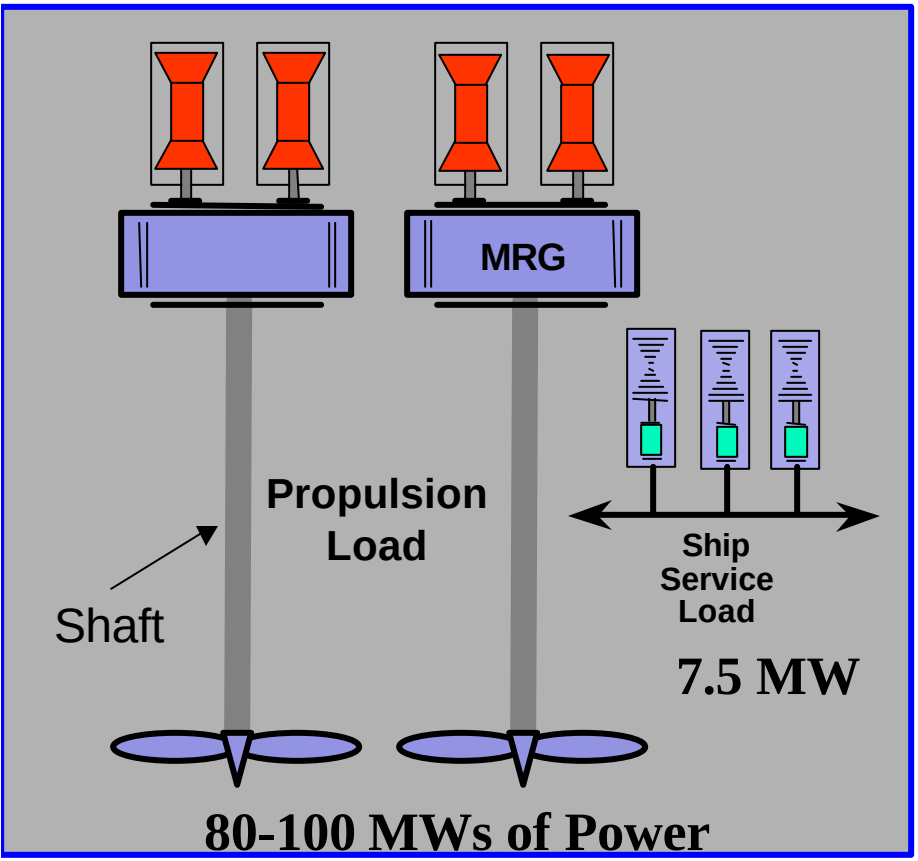
"Changes in Propulsion Systems Fundamentally Change the Character and Power of our Forces. This has Been Shown by the Movement from Sails to Steam… Electric Drive will Open Immense Opportunities for Redesigning Ship Architecture… and Allocating a Great Deal More Power to Warfighting Applications

SECNAV on 6 January 2000

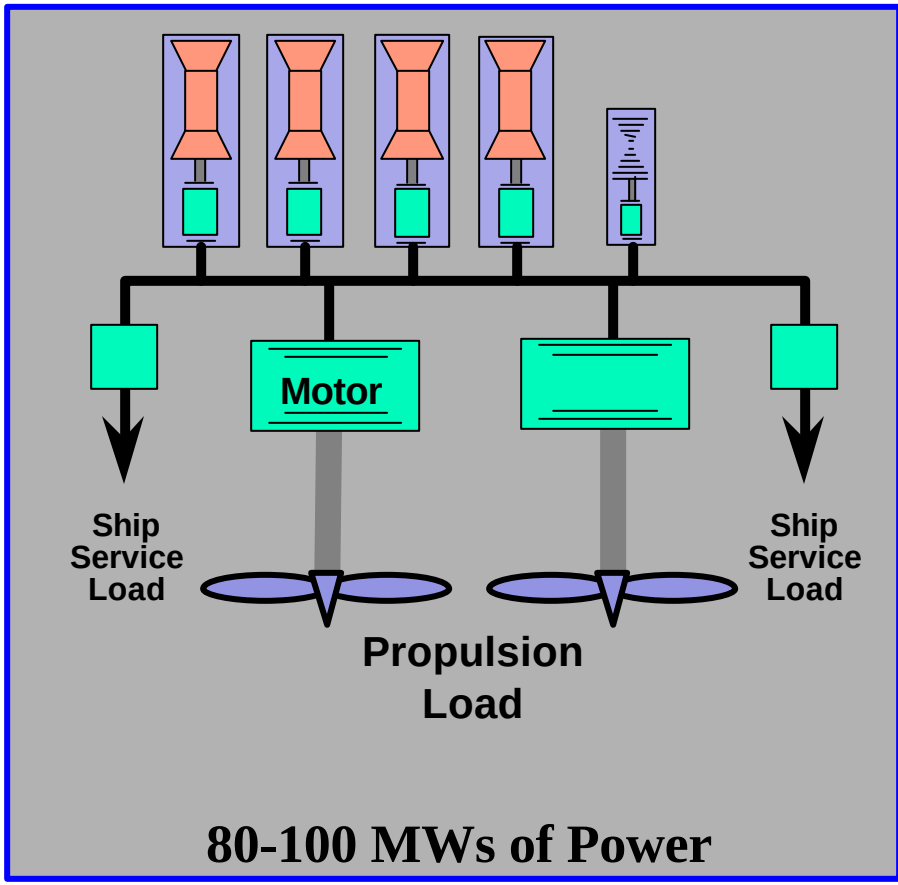
Greater Electrical Power Available for Warfighting

Comparison of Power Plants

Today's Segregated System

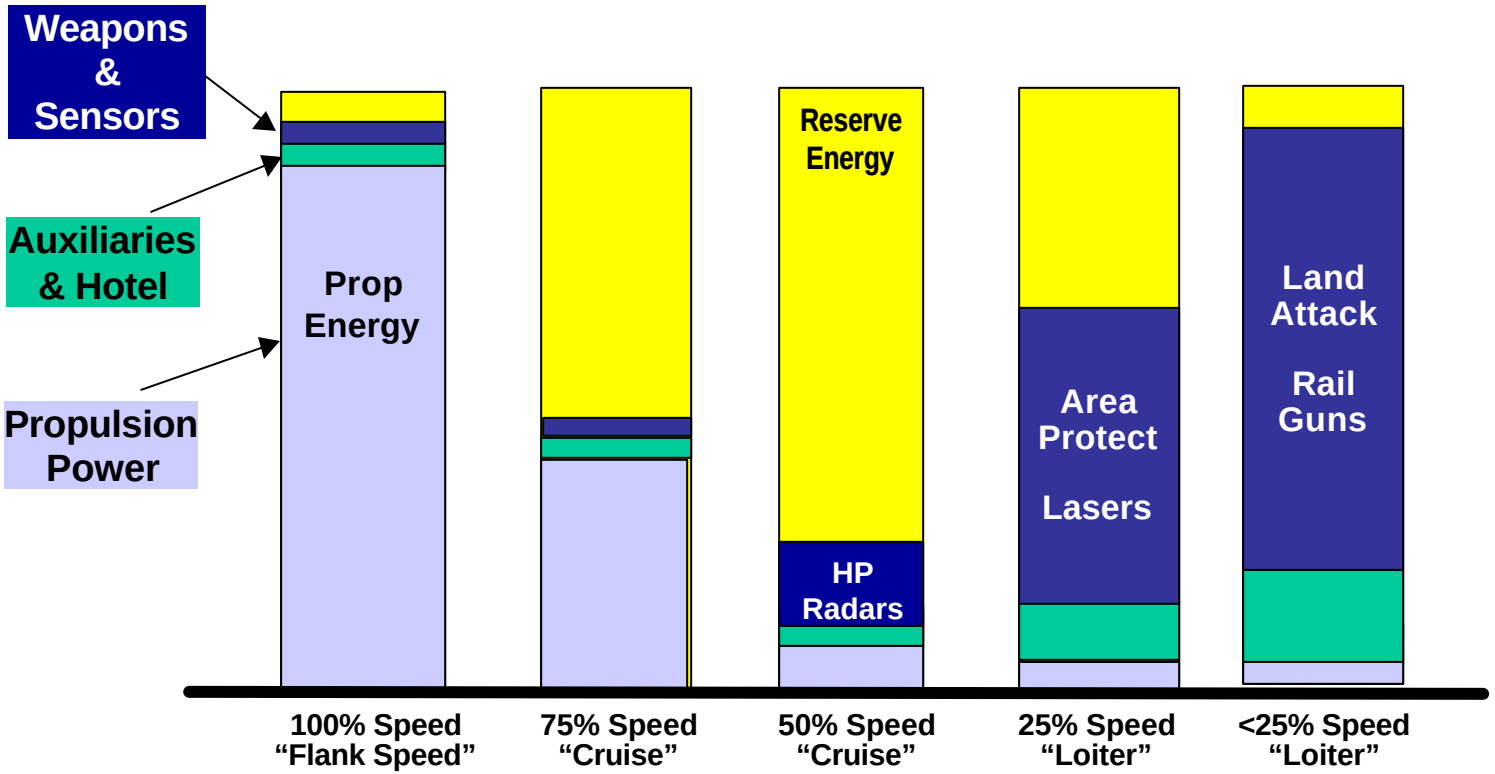


Integrated Power System



IPS Goal: Fewer Prime Movers & Fuel Savings

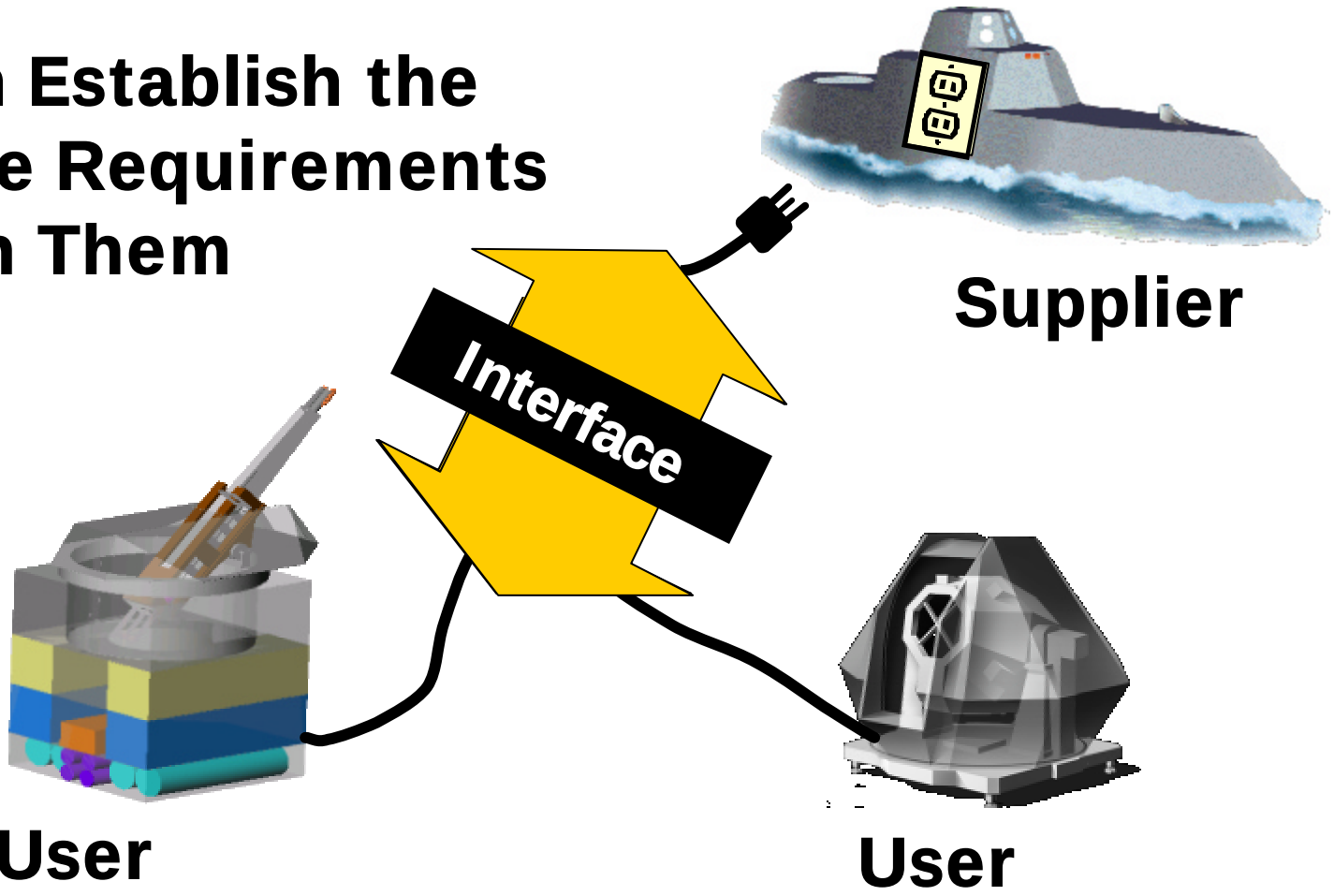
Energy Management



Dynamic Response must support Tactical Situation

Interface Changes?

. . . Then Establish the Interface Requirements Between Them

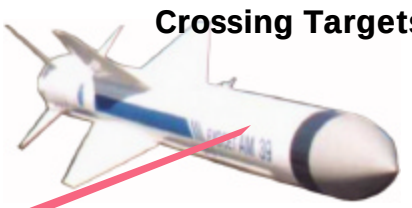


Propulsion is No Longer the Most Important Power

Potential of DEW

Very high g ASCM

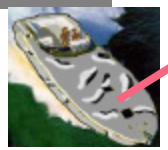
The Need: Protect the Fleet



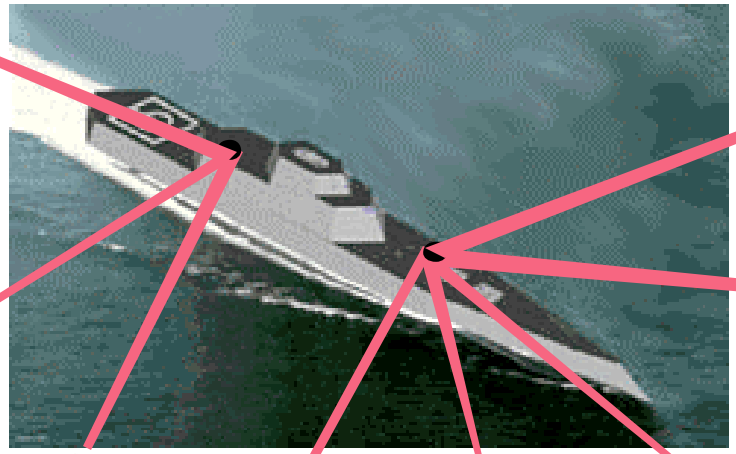
Crossing Targets

HEL eliminates maneuver advantage

HEL side shot stand alone kill



Cigarette boats



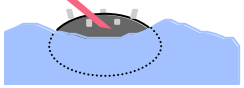
Helo & fixed wing

HEL provides option to use of expensive missiles against low-cost threats

UAVs

Rockets

"SeaDoo"



Floating mines

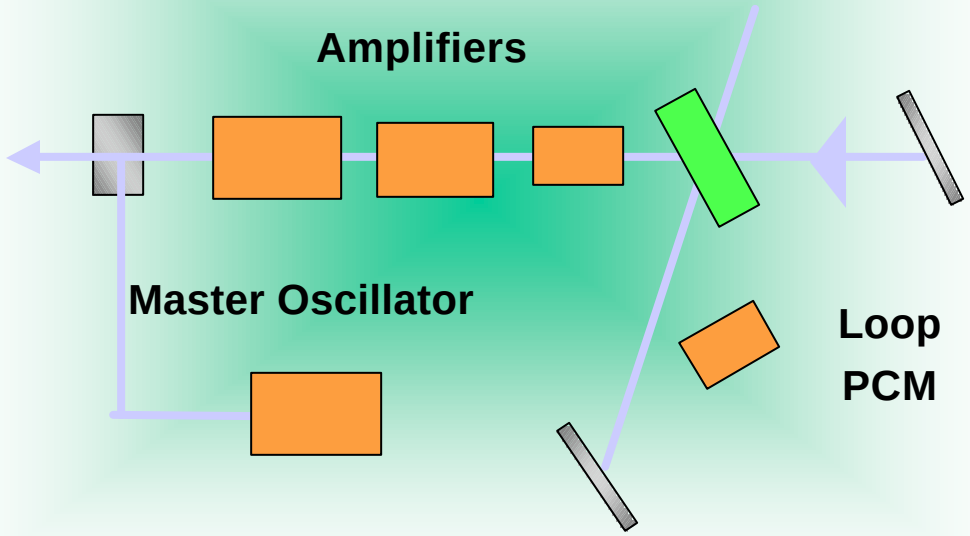
HEL engagement range increases w / elevation

Graduated Lethality

- Render the threat neutral for follow on action
- Engage until desired response is achieved
- Secondary surveillance capabilities
- Speed-of-light delivery

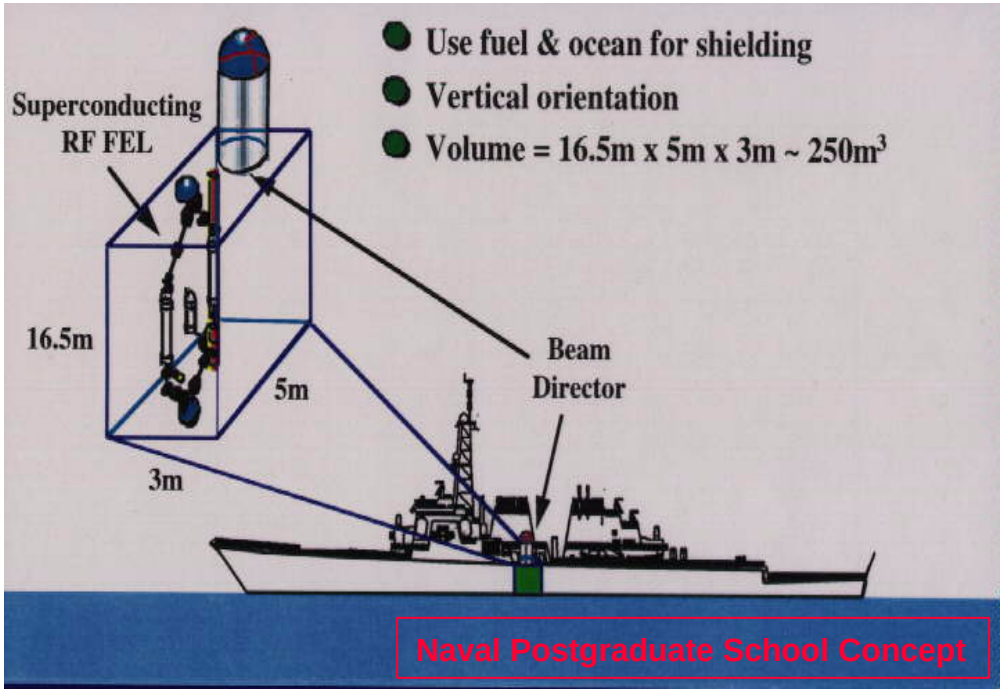
Solid State Lasers

- Operating in the Correct Atmospheric Windows for Maritime Propagation (~1.0 Micron)
- Other Services are Pursuing SS Lasers due to Perceived Smaller Size & Ruggedness
- Primary Technology Hurdle is Removing Excess Heat from the Solid Material



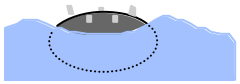
Free Electron Lasers

- Progress Made at TJ LAB (DOE) has Renewed the Interest in FEL Technology after a Negative SDI Experience
- Potential for High Power Without Toxic Waste or Thermal Management Problems
- Reducing size, Increasing Mirror Power Levels, and Injectors are the Primary Technology Hurdles



Potential of EML

ASUW



Floating Mines

NSFS

Strike

Small Boats

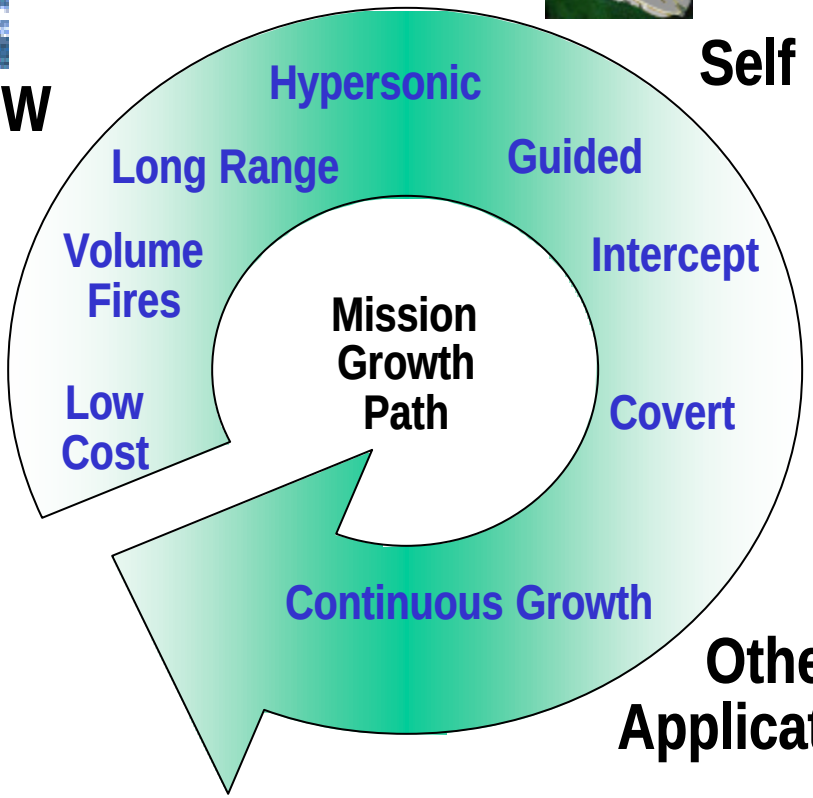
Self Defense

UCAVs

TBMD

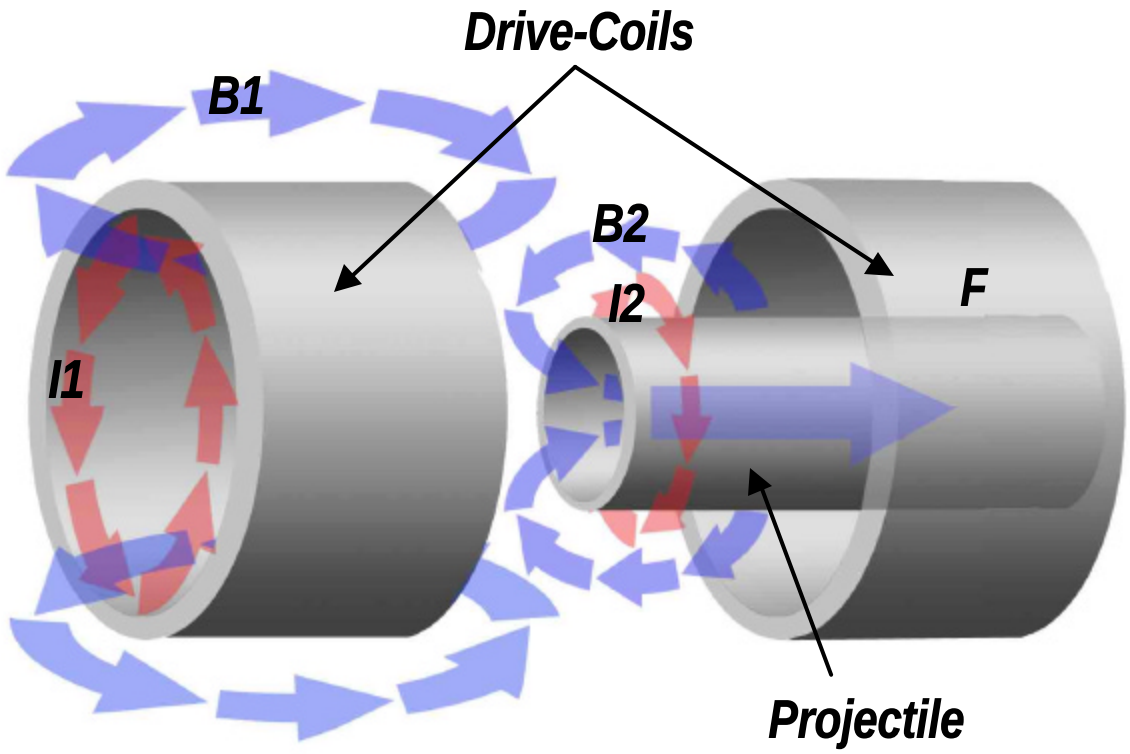
Special Forces

Other Applications



One Weapon! … Multiple Mission Areas

Coil Gun



Advantages:

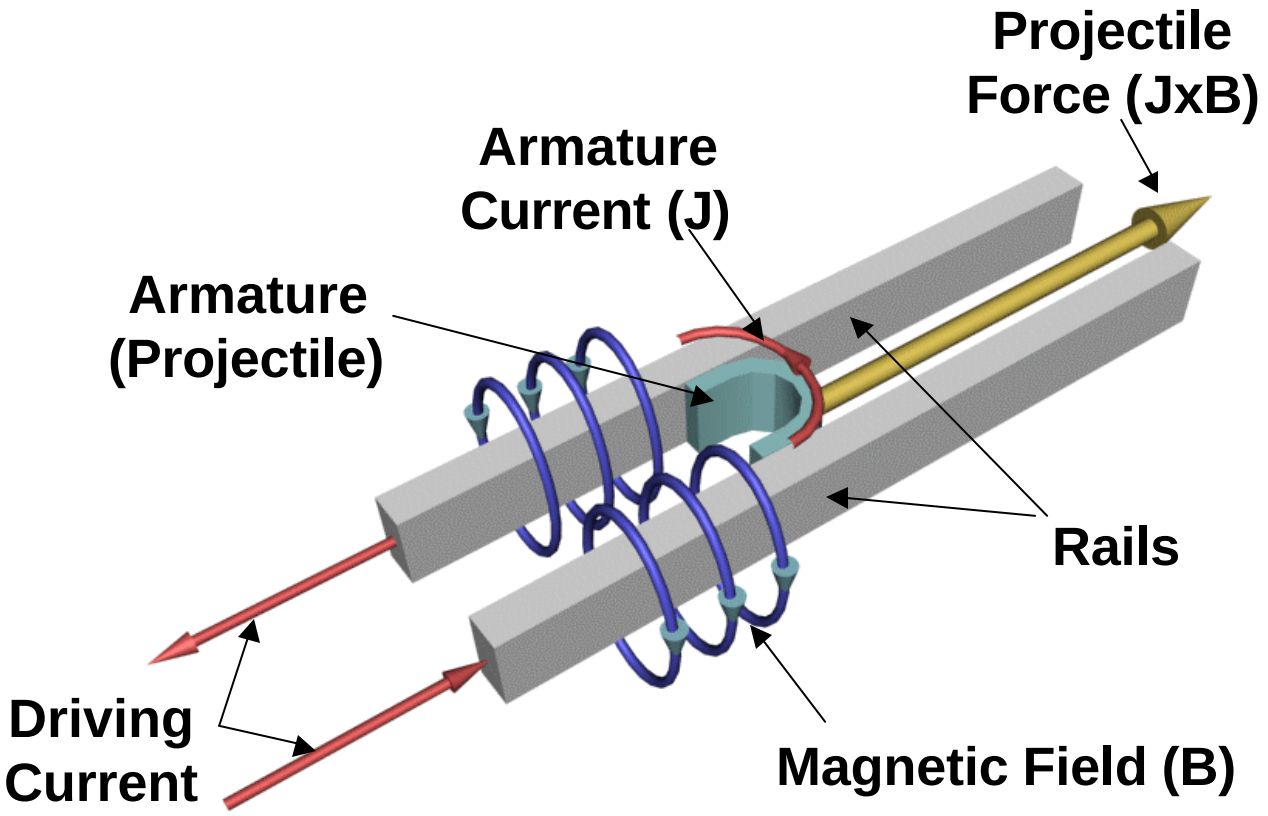
- Magnetic Levitation of Projectile
- No barrel life Issues, No barrel Wear
- Distributed Surf. Force – Uniformly along entire Barrel
- Minimum Noise & Muzzle Blast
- Best Suited for Heavy, Low Velocity Projectiles

Disadvantages:

- Precise Timing Req To Energize Multiple Coils
- Larger Barrel, Launcher Length
- Only small, low velocity guns demonstrated

Drive-Coil Current Induces an Opposing Current in the Projectile. The Resultant Magnetic Fields Repel Each Other Thereby Accelerating the Projectile

Rail Gun



Advantages:

- Simplest Power Systems
- Relatively Constant Force
- Simple EML Geometry
- Demonstrated above 2500 m/s
- Minimum Noise & Muzzle Blast
- Best Suited for Light, High Velocity Projectiles

Disadvantages:

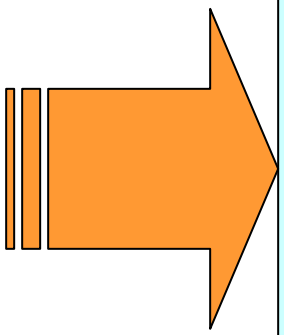
- Barrel Wear
- Barrel Cooling for Sustained Fires
- Requires Sliding Contact

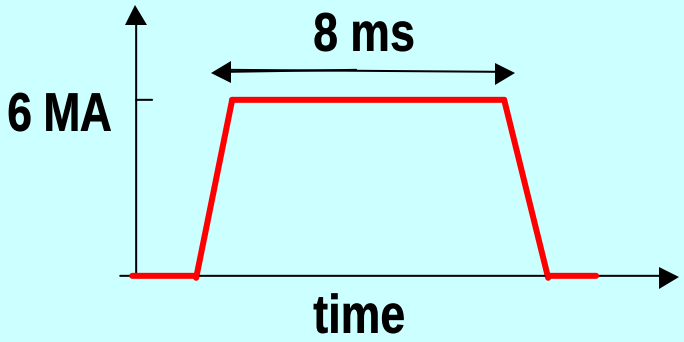
Current Flowing in the Rails Creates a Magnetic Field Which Interacts with the Current in the Armature to Generate a Lorentz (JxB) Force

Rail Gun
Pulsed Power Requirements

Notional Navy EM Gun Requirements:

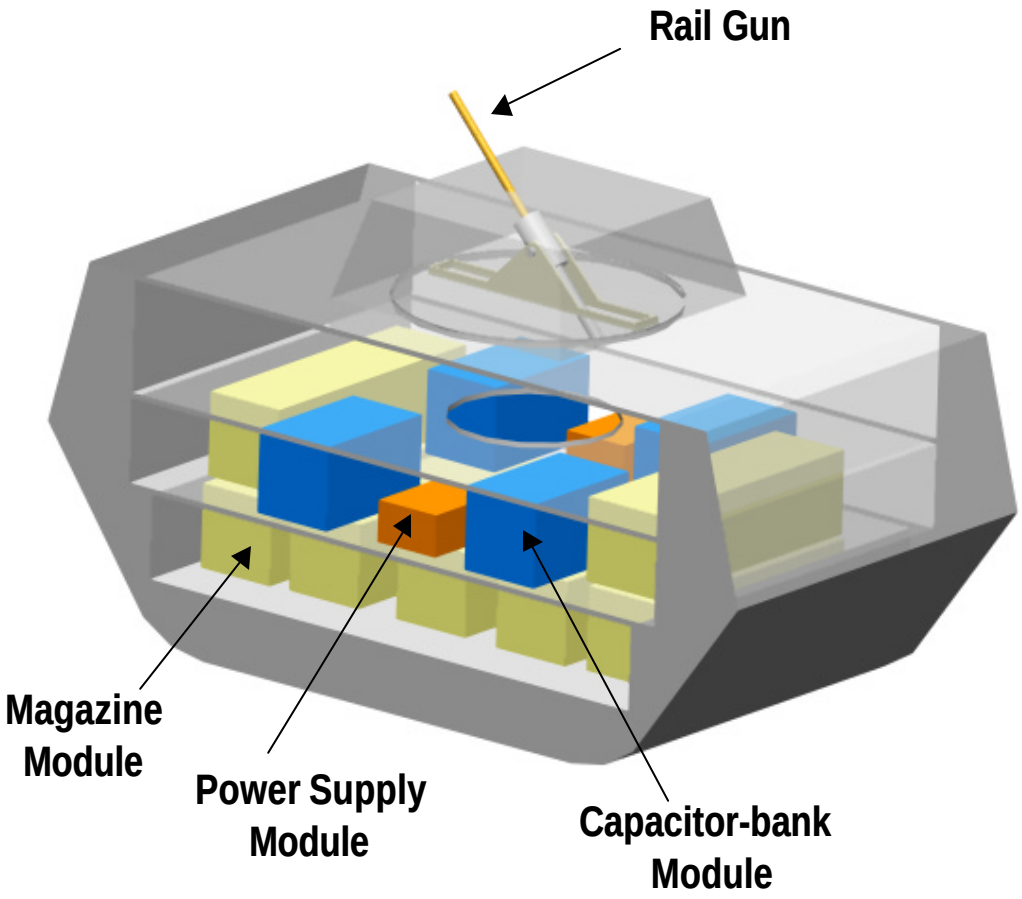
- Flt. Mass – 15 kg
- Launch Mass – 20 kg
- Launch Velocity – 2.5 km/s
- Muzzle Energy – 63 MJ
- Breech Energy – ~150 MJ
- Barrel Length – 10 m
- Peak Accel. – 45 kgee
- Firing Rate – 6 to 12 RPM





- Peak Input Voltage - ~12 kV
- Peak Charging Power - 15 to 30 MW

Pulsed Power System Conceptual Hull-Section Layout

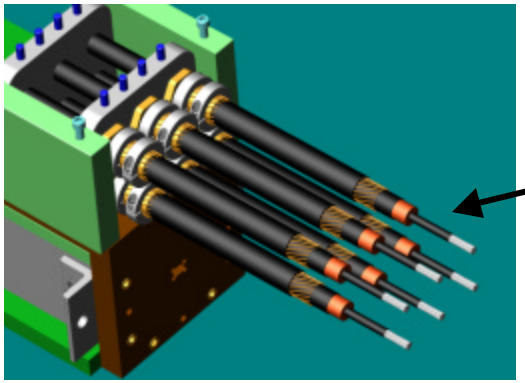


Assumptions:

- 200 MJ Capacitor-Bank
  - 2.5 MJ/m^3 Capacitors
  - 50% of Volume for Auxiliaries
- Charging Peak Power
  -15 MW (1 MW/m^3)
- 10 m Barrel Length
- Hull Section:
  - H x W x L: 13m x 30m x 15m

Smaller Projectile Promotes Increased Stowage

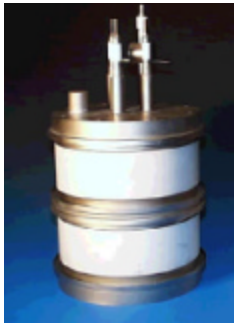
Pulsed Power System Major Technology Areas



Electric Weapon

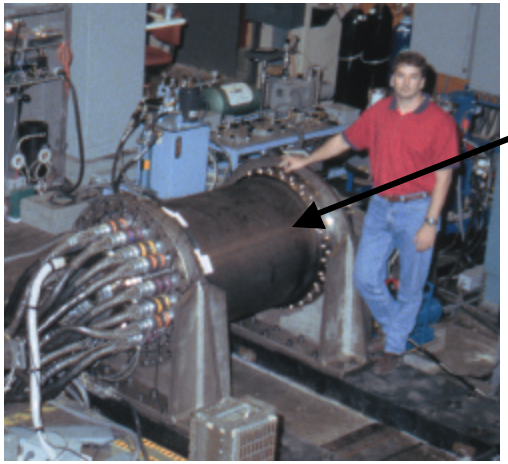
Cable

Switch / Rectifier



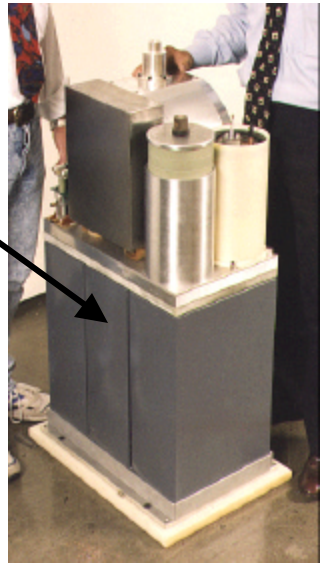
Pulsed Alternator

Capacitor Bank



Motor

Charging Power Supply



IPS High Power Bus

Electric Weapons Approach

- Begin with "Systems Perspective"
  - Threat and Weapon Effectiveness
  - Operational Prospective
  - Total Ship Systems Engineering
  - Integrated C4ISR, Weapons and Platform Services
  - Multi-Ship Class & Battleforce Applicability

- System Integration Requires:
  - Developing Dynamic Power Management
  - Multi-Function Power Conversion to Minimize Redundant Power Supplies
  - Accurately Defined Pulsed Power Charging Profile

Platform Considerations

- Naval Architecture
  - Recoil Impact to Ship Structure
  - Arrangement of Pulsed Power, Cabling and Magazines
  - Personnel Safety
- Thermal Management Issues
  - System Efficiency 5-50%
  - Electronics & Energy Storage Components
  - Transfer of Heat to Seawater
- Magazine Benefits
  - Simplifies Magazine, potentially eliminating
  - Projectile Storage Volume Increases
  - No Explosive Warheads, Propellants, or Rocket Motors

Electric Weapons Benefits

- Enhanced Ship Survivability
  - Greater Ship Stand-off
  - Eliminate Explosive Warheads
  - Eliminate Prop Charges & Rocket Motors
- Faster Time of Flight
- Increased Range
  - Increased Littoral Coverage
  - Greater Ship Mission Flexibility
- Greater KE Provides Higher Lethality
- Reduced Cost
  - Enables Volume Fires
  - Simplified Logistics, no Energetics Tail

Organizational Considerations

- Electric Ship
  - PMS 510 (PEO S)
  - SEA 05
- Directed Energy Weapons
  - PMS 405 (SEA 53)
- Electro-Magnetic Gun
  - PM Under Development

Naval Surface Warfare Center Carderock, MD

- **Lead for Ship Systems**
- **Philadelphia Sys Eng**
- **Aux Sys Dev**
- **Ship System Demonstrations**

Naval Surface Warfare Center Dahlgren, VA

- **Mission Assessments**
- **Lead for Weapons Development**
- **Interface Definition and Control**
- **Combat Weapon Demonstrations**

Conclusions

The Electric Warship initiatives address three critical components of the warfare problem:

Time - Rate - Distance